NJF seminar 391: Fruits and berries: New crops and new uses. Non-traditional production and utilisation of fruits and berries: Sweden, 18-20 Sept 2006

Suitability of raspberry and blackcurrant cultivars for utilization of frozen berries in dessert and for getting of products with high contents of bio-active compounds

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Abstract
Frozen berries of 15 raspberry and 32 blackcurrant cultivars, grown at Latvian Fruit growing institute, Dobele, Latvia, were tested for chemical composition (ascorbic acid, anthocyanins, soluble solids) and physical properties (drip loss and friability for raspberries, berry weight for all berries). Agronomical parameters (productivity, winter hardiness, disease and pest hardiness) were included in an overall evaluation of cultivars as an average from experts' estimates. Multi-criteria analysis (Мартинов, 1987) was used to establish a complex value of genotypes and to select the best cultivars for utilization of frozen berries in dessert and in production of product with high contents of bioactive components. The most suitable cultivars for utilisation berries in dessert are raspberry cultivars 'Tomo', 'Brigantina' and 'Bryanskii Rubin', and blackcurrant cultivars 'Detskosel`skaya', 'Yadrenaya', 'Joniniai', 'Chernii Kentavr', 'Selechenskaya' and 'Mara'. They were conspicuous with big berries and low acid/sugar ratio as well as with little drip loss after thawing and low friability level in frozen raspberries. The most suitable cultivars for utilisation berries in production of products with high contents of bioactive components: ascorbic acid and anthocyanins, are raspberry cultivars 'Sputnitsa', 'Ariadne', 'Bryanskii Rubin' and 'Brigantina' and blackcurrant cultivars 'Iyunskaya', 'Detskosel`skaya', 'Vernisazh', 'Vakariai', 'Triton', 'Titania' and 'Joniniai'.

Key words: Raspberries, blackcurrants, Multi-criteria analysis, bioactive components, frozen.

Introduction

Raspberries and currants are traditional berries in our region. Their importance in the diet is connected with the content of physiologically active compounds and vitamins they have more than most of the tropical fruits. But there is a tendency of recent years in Latvia to decrease the consumption of local fruits and berries and replace them with easy available tropical fruits. Therefore one of the main tasks is to enlarge the availability of local fruits and berries all the year round.
Many different blackcurrant and raspberry cultivars are recommended for commercial growing in Latvia. Unfortunately, neither commercial nor other cultivars are tested for suitability frozen storage and production of different products, including functional foods. Moreover, most of cultivars, well examined and demanded by Western European processing companies, cannot be grown in Latvia because of different climate. And, properties of those, which can be grown there, can differ. Therefore, it is necessary to examine suitability to freezing and frozen storage of cultivars, grown in Latvia. Consequently, then it would be possible to choose the best cultivars for processing out of very large number of cultivars, and recommend them for growers.

Materials and methods

Frozen berries of 15 raspberry and 32 blackcurrant cultivars, grown at Latvian Fruit growing institute, Dobele, Latvia, were tested for following chemical composition:

- Contents of ascorbic acid by iodine method (Давров и Штенберг, 1950) in fresh and frozen berries, and frozen blackcurrant purees;
- Contents of anthocyanins by spectrophotometric method (Fuleki and Francis, 1968) in fresh and frozen berries, and frozen blackcurrant purees;
- Contents of total (titrable) acids, by titration with 0.1 N NaOH (ISO 750:1998) in fresh and frozen berries, and frozen blackcurrant purees;
- Contents of soluble solids by refractometer ATAGO N20 (ISO 2173:2003) in fresh and frozen berries;

The physical properties tested in this experiment were:

- Drip loss after thawing in raspberry berries – berries thawed at temperature +17 - +20 °C, percent of drip loss from initial mass is calculated;
- Friability of frozen raspberries – frozen berries were steadily shaken in freezing chamber VTK 201 3 minutes at temperature -20±2 °C;
- Berry weight for all berries (the weight of 100 berries).

Agronomical parameters (productivity, winter hardiness, disease and pest hardiness) were included in an overall evaluation of cultivars as an average from experts' estimates and the same agronomical parameters were used for every year.

Principles of Hierarchy modeling and Multi-criteria analysis (Мартинов, 1987) were used to establish a complex value of genotypes. The analysis allows comparing the complex values of different genotypes, using various parameters in different measurement systems. Each trait group and individual trait has specific contribution coefficient in the final evaluation. The best variety will appear to be as close as possible to the desired (optimum) value in parameters as many as possible. Multi-criteria analysis coefficient *SD* was calculated, according to formulae 1 and 2:

$$SD = \sum_{i=1}^{N} \omega_i (I_i - x_{av.,i}) / s_i \quad \text{or} \quad SD = \sum_{i=1}^{N} \omega_i \delta_i / s_i \text{ , where} \qquad (1)$$

SD – multi-criteria analysis coefficient value for the cultivar;
i – quantitative trait;
I_i – desired value of the trait *i*;
$X_{av,\,i}$ – actual value (average) of the trait *i* for the cultivar;
ω_i – contribution coefficient of the trait *i*;
s_i – standard deviation;
δ_i – deviation of the actual value of the trait *i* from teh desired value;
N – number of the traits.
If $(I_i - x_{av,\,i})$ or $\delta_i < 0$, then modulus (positive value) of the deviation is used.

$$\omega_i = p_k N / n_k \; ; \quad \sum p_k = 1 \text{ and } \sum n_k = N \text{ , where} \qquad (2)$$

p_k – contribution of the trait group *k*;
n_k – number of the traits in group *k*.

The obtained multi-criteria evaluation coefficient (*SD*) describes deviation of the genotype from desired values; consequently, the best genotype will have the least *SD* value. This analysis helps to select the most suitable cultivars for production of different frozen berry products. Multi-criteria analysis of raspberries and blackcurrants were performed to select the best cultivars for utilization of frozen berries in dessert, where

the highest contribution coefficient was given to friability, drip loss, the berry weight, and acid/ sugars ratio in raspberries, and berry weight and acid/sugar ratio in currants. The highest contribution for getting of products with high contents of bio-active compounds was given to the contents of ascorbic acid and anthocyanins in frozen berries. Data from every year was included in analysis as separate parameter.

Results and Discussion.

1. Evaluation of frozen raspberries

'Tomo', 'Brigantina', and 'Bryanskii Rubin' were the most suitable cultivars for utilization of frozen berries in dessert (Figure 1). The highest evaluation of these cultivars was caused by their low friability (average of years 2001 – 2003 16 – 25 % of berries were crumbled) and small to medium drip loss rates (average 17 to 19 %). 'Comet', 'Ariadne', and 'Newburgh' was found not suitable for utilization of frozen berries in dessert, because their evaluations differed from desired values the most – their *SD* values was higher than $SD_{av} + s$ =163.07.

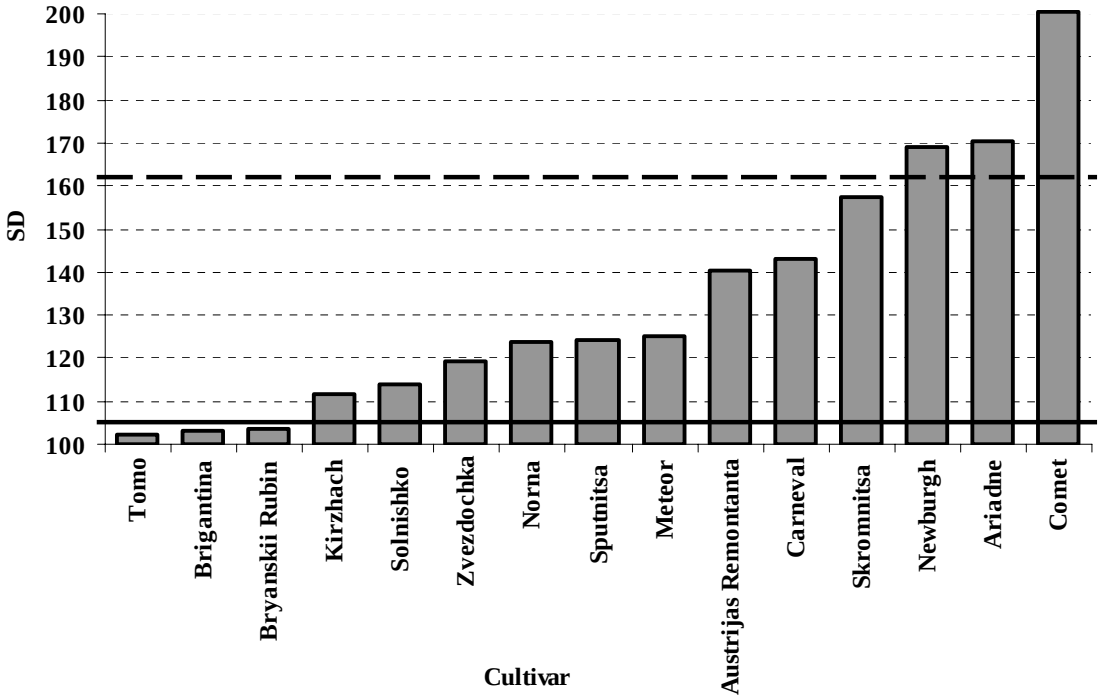

Fig. 1. Multi-criteria evaluation of raspberry cultivars for suitability of frozen berries to dessert
$SD_{av} - s = 104.61$ $SD_{av} + s = 163.07$

The highest contribution for getting of products with high contents of bio-active compounds was given to the contents of ascorbic acid and anthocyanins in frozen berries. The best cultivars therefore were 'Sputnitsa' and 'Ariadne', which was followed by 'Bryanskii Rubin' and 'Brigantina' (Figure 2). The cultivars 'Sputnitsa' and 'Ariadne' had the highest total anthocyanin content (average 59.0 and 56.9 mg 100 g^{-1}, respectively), and 'Ariadne' also one of the highest contents of ascorbic acid (average 16.0 mg 100 g^{-1}). 'Bryanskii Rubin' and 'Brigantina' had medium high contents of anthocyanins (average 35.0 and 39.4 mg 100 g^{-1}, respectively). Generally, most of the cultivars had rather similar chemical composition and only two cultivars, 'Skromnitsa' and 'Comet', had multi-criteria evaluation coefficients higher than $SD_{av} + s$ =168.42, and therefore were considered to be not suitable for getting of products with high contents of bio-active compounds.

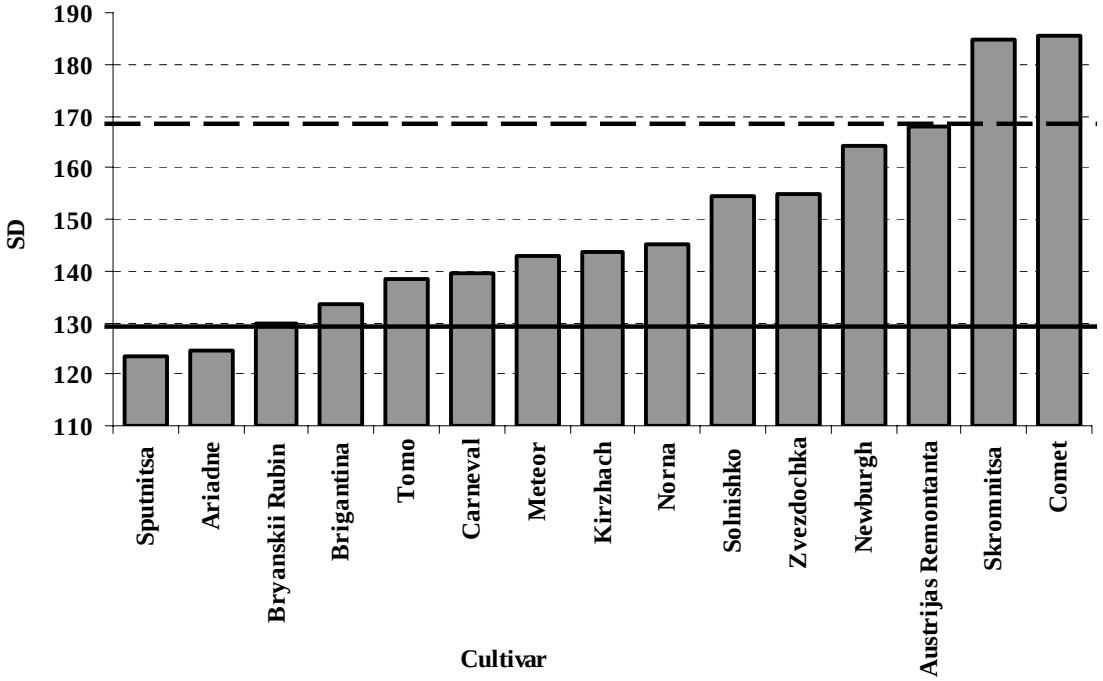

Fig. 2. Multi-criteria evaluation of raspberry cultivars for getting of products with high contents of bio-active compounds

——— SD_{av} - *s = 129.34*

— — SD_{av+} *s = 168.42*

2. Evaluation of frozen blackcurrants

The highest contribution coefficients for utilization of frozen blackcurrant berries in dessert were assigned to berry weight and acid/sugar ratio. The best cultivars, according to multi-criteria evaluation, were cultivars 'Detskosel`skaya', 'Yadrenaya', 'Joniniai', 'Chernii Kentavr', 'Selechenskaya', and 'Mara' (Figure 3). All of the previous cultivars had medium large or large berries (average 0.77 – 1.92 g), and berries of cultivars 'Detskosel`skaya', 'Selechenskaya' and 'Joniniai' had also pleasant taste (low acid/sugars ratio – in average 0.24, 0.22 and 0.36, respectively), therefore these three cultivars are the best for desert. Berries of the cultivar 'Detskosel'skaya' lack specific, strong blackcurrant flavour that somewhat reduces utilization possibilities of them. However, the sweet berries are very useful for desert, because some people do not like specific and strong blackcurrant flavour and, in this case, that flavour is even undesirable

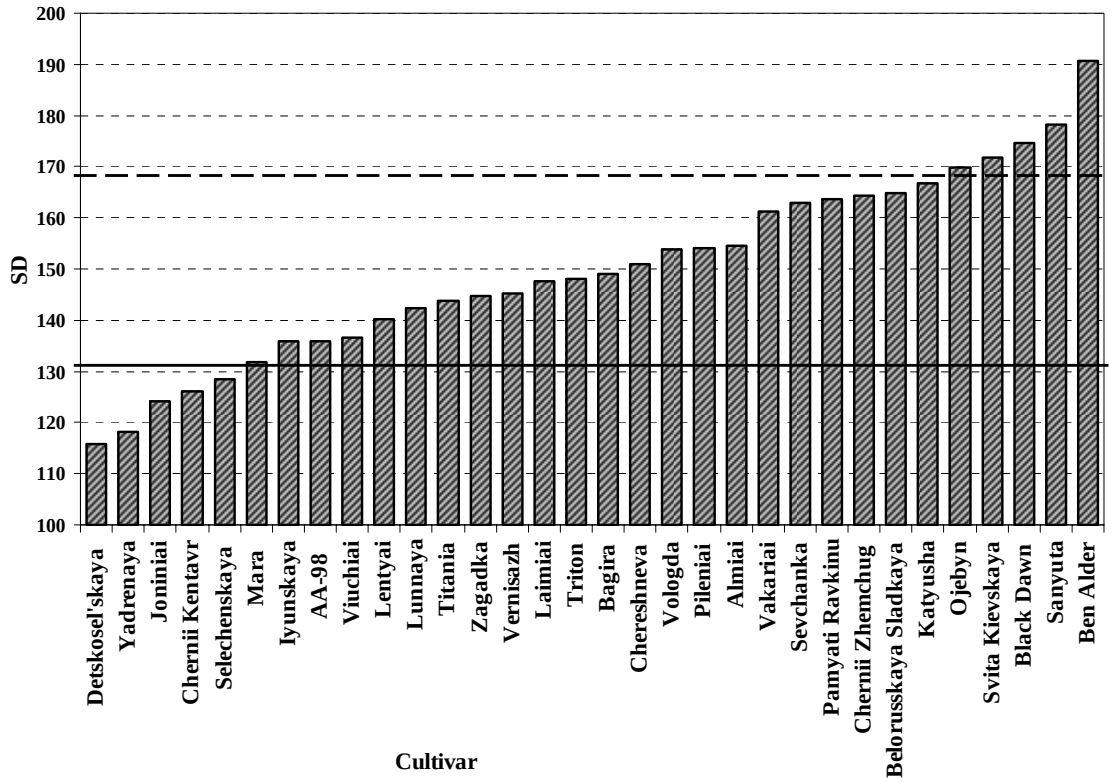

Fig. 3. Multi-criteria evaluation of blackcurrant cultivars for suitability of frozen berries to dessert

——— SD_{av}- s = 131.71

— — SD_{av+} s = 168.03

The best blackcurrant cultivars for getting of products with high contents of bio-active compounds was ‘Iyunskaya’, ‘Detskosel`skaya’, ‘Vernisazh’, ‘Vakariai’, ‘Triton’, ‘Titania’, and ‘Joniniai’ (Figure 4), which were characterized by high contents of ascorbic acid and anthocyanins.

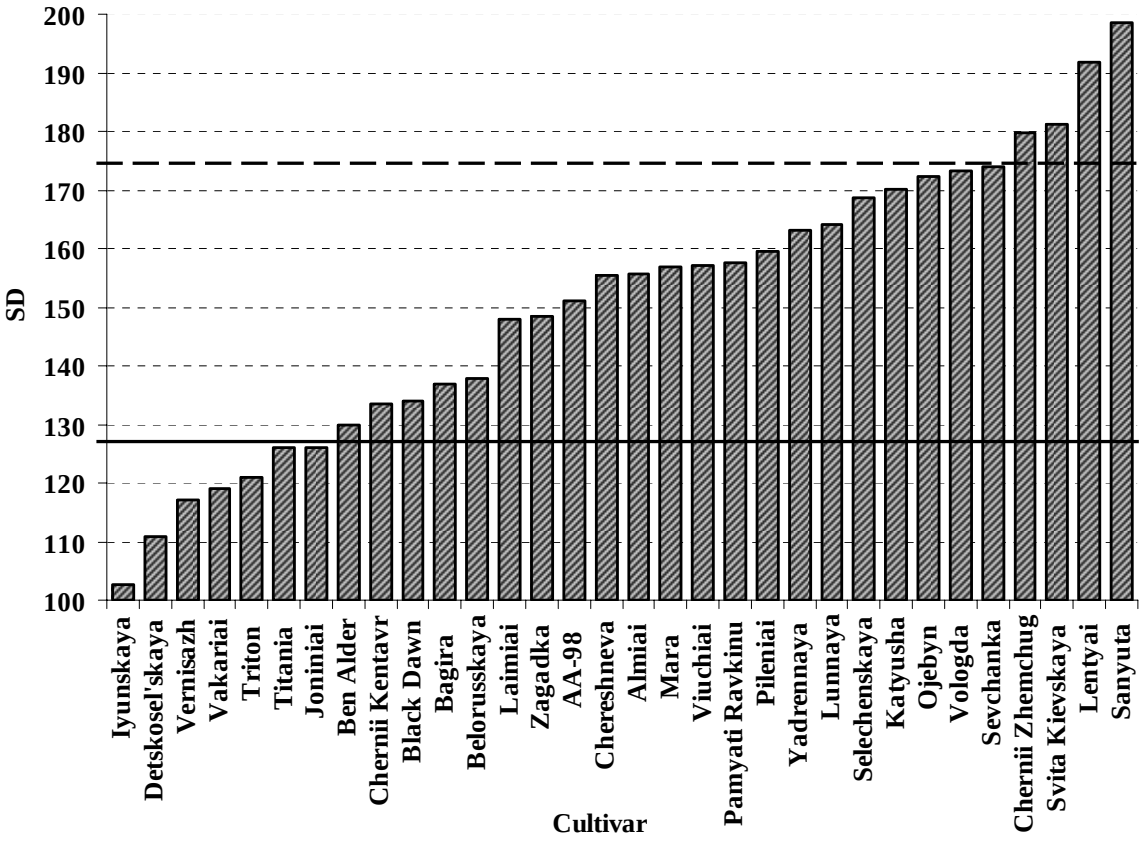

Fig. 4. Multi-criteria evaluation of blackcurrant cultivars for getting of products with high contents of bio-active compounds.

——— SD_{av} - s = 126.54

— — SD_{av} + s = 174.76

Berries of 'Iyunskaya' had high both anthocyanins (average 250.8 mg 100 g^{-1}) and ascorbic acid (average 219.6 mg 100 g^{-1}) content, whereas berries of cultivars Detskosel`skaya', 'Vakariai', and 'Joniniai' had high contents of ascorbic acid (average 238.8, 224.7 and 249.4 mg 100 g^{-1}, respectively) and medium contents of anthocyanins (184.1, 190.9 and 152.3 mg 100 g^{-1}, respectively). Berries of 'Vernisazh', 'Triton', and 'Titania' had much anthocyanins (269.4, 281.8 and 247.6 mg 100 g^{-1}, respectively) and medium contents of ascorbic acid. The other traits, though included in analysis, had less importance (less contribution coefficients) in this analysis. Four cultivars: 'Chernii Zhemchug', 'Svita Kievskaya', 'Lentyai', and 'Sanyuta' had less valuable chemical compositon and they cannot be used for getting of products with high contents of bio-active compounds.

Conclusions

1. Multi-criteria analysis is useful for selection of suitable cultivars for production of frozen berries in dessert, of products with high contents of bioactive components, and processing.
2. The most suitable cultivars for utilisation berries in dessert are raspberry cultivars 'Tomo', 'Brigantina' and 'Bryanskii Rubin', blackcurrant cultivars 'Detskosel`skaya', 'Yadrenaya', 'Joniniai', 'Chernii Kentavr', 'Selechenskaya' and 'Mara'. They were conspicuous with large berries and low acid/sugar ratio as well as with little drip loss after thawing and low friability in frozen raspberries.

3. The most suitable cultivars for utilisation of berries in production of products with high contents of bioactive components: ascorbic acid and anthocyanins, are raspberry cultivars ‘Sputnitsa’, ‘Ariadne’, ‘Bryanskii Rubin’, and ‘Brigantina’ and blackcurrant cultivars ‘Iyunskaya’, ‘Detskosel`skaya’, ‘Vernisazh’, ‘Vakariai’, ‘Triton’, ‘Titania’, and ‘Joniniai’.

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Special berries to the market – a development project cutting the local agro-food chain

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Abstract
The project "Special berries to the market" (originally in Finnish "Erikoismarjat markkinoille") runs in 2005-2007 in the region of Kainuu in eastern Finland. The aim of the project is to develop cultivation and marketing of wild berries, especially the cloudberry (*Rubus chamaemorus* L.), cranberry (*Vaccinium oxycoccos* L.), arctic bramble (*Rubus arcticus* L.) and wild strawberry (*Fragaria vesca* L.). The project is executed as cooperation of many institutes specializing in different areas related to berries.

Key words: wild berries, cultivation, cloudberry, cranberry, wild strawberry, arctic bramble

Introduction

"Special berries to the market" (originally in Finnish "Erikoismarjat markkinoille") is a project whose purpose is to develop the local berry industry in the Kainuu region in the eastern Finland. The objectives of the whole project are to create and sustain employment in berry cultivation and processing and also create more possible means of livelihood in often peripheral areas of Kainuu.

The main emphasis is on the cultivation and product development of wild berries, especially the cloudberry (*Rubus chamaemorus* L.), cranberry (*Vaccinium oxycoccos* L.), arctic bramble (*Rubus arcticus* L.), and wild strawberry (*Fragaria vesca* L.). The project covers the whole know-how chain from the ecology of natural habitats through domestication and cultivation to food production and health effects. The total funding of the project is 381.980 € and the time frame of the project is from 2005 to 2007.

The project can be also seen as a continuum of past development work in the domestication of wild berries, mainly the cloudberry, done in Kainuu region since 1990's.

Local know-how chain…

The know-how chain in the development of cultivation and marketing of wild berries consist of four different parties. At the beginning of the know-how chain, the Friendship Park

Research Centre of the Kainuu Regional Environment Centre collects information from the cloudberry's and cranberry's natural habitats. This includes data of flowering and yielding in different habitats, frost hardiness, and sexual distribution and variation of cloudberry flowers. Berry yields from different habitats are collected for latter analysis to find out variations in nutritional quality of the berry. Also the possible effect of glycine betaine -spraying on frost hardiness of cloudberry flowers is tested on natural sites.

Next, MTT Agrifood Research Finland's Sotkamo research station has the responsibility of the cultivation trials and the collation of cultivation knowledge. The trials include comparison of the cloudberry's and cranberry's natural and bred clones, cultivar trials of the arctic bramble and wild strawberry, simple farm trials of cultivation techniques (e.g. pest management, fertilization and propagation of the cloudberry), testing effects of biological soil amendments and irrigation on cloudberry growth and a survey to find out the influence of soil's physical properties to the growth and yielding of the cloudberry on natural and man-made sites.

Compositions of bioactive compounds in berries are investigated in the Laboratory of Biotechnology, Kajaani University Consortium, University of Oulu. In the analyses, total phenolic compounds, anthocyanins, flavonols including myricetin and quercetin, carotenoids, seed oils (fatty acids), vitamin C, fibres, organic acids, and proteins are studied. The results will be utilized in marketing and product development. Also the quantity of main aroma forming compounds of the arctic bramble and wild strawberry varieties will be analyzed to find out if varieties differ in their taste and aroma and therefore in their value to processors or users.

Finally, ProAgria Kainuu Rural Advisory Centre (project manager Mrs Heli Pirinen) leads the project and has the responsibility of knowledge transfer. Knowledge is transferred to farmers and entrepreneurs by advisory farm visits, cultivation guide booklets and the project homepage (www.marjamaa.fi), where trial results and collated cultivation knowledge is published. Also education on different subjects and study trips are arranged. ProAgria Kainuu has the main role in the cooperation with the enterprises and in the marketing and product development. The marketing skills of local entrepreneurs is developed by education and by creating a network of entrepreneurs in the berry business to facilitate a closer cooperation.

…promoted by global expertise

International cooperation supports local development work done in Kainuu region. Important partners in the project are The Institute of Biology of Karelian Research Centre of Russian Academy of Sciences and the Ministry and Information Centre of the Republic of Karelia. Russian partners share their knowledge of cranberry cultivation that is gained through decades of cranberry cultivation research carried out in Russia. Russian plant material is also supplied to trials carried out in MTT Sotkamo research station and berry farms.

Cooperation is also done with Peatland Ecology Research Group of the University of Laval in Quebec, Canada. A Canadian researcher and a trainee were working in MTT Sotkamo during summer 2006, carrying out experiments on the cloudberry and sharing their expertise on the ecology and cultivation of the cloudberry.

A group of people working with development of the cloudberry cultivation in Norwegian Bioforsk Nord Holt research station has also been visiting the project and sharing their knowledge of cloudberry cultivation.

Results

A report of the trials carried out during the project will be published in a final report after the project is completed. Also articles in professional magazines will be published. Some results will also be published in scientific papers, and presentations can be given in suitable seminars.

Results of the whole project will be seen only after some years. As an immediate result, however, knowledge and skills of the participating farmers and entrepreneurs have increased. Some increase in the cultivated area of the cloudberry has been noticed, and interest in the cultivation of cloudberry, cranberry, arctic bramble and wood strawberry has increased. Russian and Estonian cultivars of the cranberry not available in Finland before have been taken into production and a promising natural clone of the arctic bramble has been taken to propagation for farm trials. Promising cloudberry strains have been observed in clone comparison trial. The project has gained publicity in local and national media and thus increased interest in the cultivation of wild berries.

Acknowledgements

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Soft fruit production in a global perspective

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Abstract
The production of soft fruit for the fresh market is undergoing a big change because of many reasons: reduction in available pesticides, demand for residue-free fruit, healthy image, changes in cultivation e.g. tunneling and season extension, market decides cultivars, new cultivars but also resistance-breaking strains of pests and diseases. We will see an increasing demand for the future.

Also the production of soft fruit for processing will have more focus on healthy aspects. The number of products will undergo a dramatic change for the future. Before establishing new plantings growers should always secure there is a link to an end producer. Growers in all countries have this responsibility. If not, things will happen like in Poland. An uncontrolled production will take place and the world market price will fall dramatically far below production cost.

My vision is that the big environmental profits will be gained by the conventional growers who step by step are changing in direction to organic farming. In Strawberry for example the Swedish conventional growers have adopted quite a big use of physiologically active agents against P&D, biological control, damage threshholds, monitoring and control systems and decision support systems. They are on the way, but there is still a long way to travel.

Production and consumption

The production and consumption of soft fruit is constantly increasing. The reason for this increase is obvious

* health benefits (nutritional and medical value)
* year-round availability
* good quality
* reasonable prices

Worldwide Strawberry production for example has increased from 2.5 million tons 1990 to 3.2 million tons 2003 on a stable acreage of about 210 000 ha. During this period the production per ha has increased from 11.7 to 15.3 tons due to better varieties and more advanced production technique. USA has the highest per capita consumption in the world. It has constantly increased from 1.6 kg 1980 to 3.3 kg 2003. This represents a general trend also for other soft fruit crops and countries.

The worldwide production figures for Raspberry are 0.5 million tons/117 000 ha, Black and Red Currant 0.65 million tons/644 950 ha, Blueberry 0.23 million tons/49 500 ha and Gooseberry 0.18 million tons/29 000 ha. Corresponding figures for Orange is 62 million tons/3 670 000 ha, which shows that soft fruit production has a very big potential in the future if market shares can be taken.

What happens in Poland is extremely important for the rest of the world. In Poland the production of Strawberry is 181 000 tons, Currants 194 000 tons, Raspberry 50 000 tons, Gooseberry 20 000 tons and other crops 48 000 tons. Poland has an old tradition in soft fruit production for the industry. After entering the EU they now undergo a dramatic change towards the fresh market in Strawberry, Raspberry and Blueberry.

Production patterns

The growers tend to extend their production in order to be more attractive to the market. They want to present their products from early season until late. The buyer is much more interested in one grower´s products, when he can supply this buyer with products during a longer period. Then he automatically will be a faithful buyer also when the market is full of products.

In Holland Strawberry is produced from April until December. Very small quantities are produced during the summer when the production in Europe is big and the prices are low. This out of season production takes place in heated greenhouses, tunnels, and tabletops by using frigoplants normally planted in July. They will give a smaller yield in the autumn followed up by a bigger one in springtime.

If you plant big frigoplants of Strawberry in springtime you can harvest 60 days after planting. When planting is made throughout the season you can achieve a continuous yield from one single variety. In Belgium a similar system has been developed for Raspberry. Plants are taken out from the freezer and planted every 14 days. This gives you a continuous yield during the summer from one single variety.

In Germany many Strawberry growers establish A+ plants 1st of May and they harvest a small yield already 60 days after planting, when the strawberries are more expensive. Next year the harvest from these plants is one month earlier. This has now been practised in Sweden with success, getting pay-back for the investments already the first year. You are getting two yields within 15 months and then you can pull out the plants. This gives you a totally different situation regarding P&D besides a very high percentage of 1st class fruit.

In the UK more than 1 000 ha of Strawberry are covered with tunnels. The quality in tunnels is superior, the yield is better, you are not depending on the weather conditions, the crop is earlier and the need of pesticides is lower. The big chains in the UK only buy Strawberries produced in tunnels. They do not accept rain as an excuse for not picking.

Also the Raspberry production has moved under tunnels in the UK. Raspberry responds even better to tunnels giving the growers a bigger increase in yield and better quality compared to Strawberry.

Everbearers in Strawberry like Flamenco and Everest have become quite popular in the UK. They are supplying the market from mid-July until frost comes yielding up to 40 tons per ha. Everbearers have never become widely used in Sweden because of grey mould. We do not have any fungicides with a shorter waiting period than 7 days. In the UK the growers can pick only after 24 hours.

Introducing tunnels could be the driver for a change, making it possible for Scandinavian growers to produce everbearers as well as primocanes in Raspberry in the future.

In Raspberry British growers more and more establish long-cane plants, +1,2m, planting up to 8 plants a row meter, 25 000 plants/ha. The cost for this plant is 13 SEK. This gives a substantial harvest already the first year, 90 days after planting. The plants will normally remain several years, but in the most extreme case the plants will be pulled out already after one season when only top quality is required.

Another way of producing Raspberry is to pick every second year. Some British and Chilean growers have tried this with success. Of course they will lose every second crop. On the other hand they can leave 50 % more canes the year you will pick. When the new canes start to grow they will be removed. The berries are picked from canes with no competition from the new ones giving more light and less humidity and a cheaper picking-cost. Normally fertilizing Raspberry is a compromise. In this case one regime can be given the year new canes are developed and another in the picking year which gives an optimal situation.

In Chile there is a big production of fresh Raspberry and Blueberry. One of the biggest companies is Hortifrut, who has a motto saying they are selling soft fruit in all parts of the world 365 days a year. This is the extreme example of an extended season. It is possible by operating on different production sites. The blueberries are shipped in CA-controlled containers.

The situation for soft fruit consumed by the industry

Many big players representing the industry claim that everybody now is looking at Super fruits that are rich in vitamins, flavanoids, anthocyanins, phenolic acids and antioxidants like Blueberry, Cranberry and Black Currant. Glaxo SmithKline (GSK) has a worldwide turnover in Ribena juice made of Black currant well over 3 billion SEK. Michael Dunsire reports they also have introduced a Blueberry Ribena. The price for concentrated Blueberry has doubled in one year to 29 Euro/kg. They are also considering an Aronia Ribena. GSK reports that China is planting a lot of all these crops including Sea Buckthorn.

In a couple of years the market can be flooded with Blueberry, very much like the situation is right now for the Black Currant. This crop is now facing a big overproduction with prices below harvesting costs. There is a trend that Black Currant experiences an overproduction every ten years. Last time it happened was in 1993. After some good years the price in Poland was only 7 Eurocent per kg in 2005. At the same time also the Baltic states have built up a big production, so this time the overproduction seems to last for a couple of years. There is a big risk that Western Europe is losing this production to low-cost countries. This happened in Strawberry for processing already 20 years ago.

Poland alone produced last year 140 000 tons of Black Currant, well covering the worldwide demand. On top of that, France, Germany, the UK and Denmark each produced about 9 000 tons. In USA, an American enthusiast, Greg Quinn in NY, right now intensively promotes Black Currant. He has alone succeeded to make it legal to grow Black Currant in almost all states. It was earlier forbidden because of a fungus hosting Black Currants and a pine. If the Americans learn to consume Currants, an enormous market will open.

The biggest company in Europe selling juice to end producers is Danish Vallö Saft A/S. They have factories in Poland and reports that Aronia (Chokeberry) is an important product today reaching almost 40 000 tons being sold at a low price. Researcher Stan Pluta reports Aronia goes 100 % for processing – concentrate, jam and frozen fruits.

In Hungary and Austria there is still a quite big production of Elderberry being processed. In Poland Elderberry is mostly being picked in the wild. However one grower has 180 ha of Elderberry and 30 ha of Sea Buckthorn. But unfortunately the market for these fruits are not existing in Poland for the moment, having obvious problems selling these fruits.

This shows that establishing new plantations of especially new crops is very hazardous. You can see it happen in Poland but also in other countries. In Estonia growers were told 5 years ago that Aronia was a profitable crop. In only a few years 900 ha were planted and when they now are ready to be harvested there are no buyers. Establishing new plantings should never be done without having a buyer or you process the crop yourself.

Mogens Christensen at Vallö Saft believes the small-scale production in Poland will cease to exist because it is hard to get pickers. There are more than 10 000 growers of Black Currant having less than 1 ha. Very soon, fewer and much bigger farms will harvest by machine.

In New Zealand there is no production of Aronia or Sea Buckthorn. Jim Grierson, NZ Co-Op reports there is a small area of Elderberry and Cranberry only for juice for the domestic market. Blueberry is expanding and some is exported fresh to Australia and Japan. NZ Black Currants are being processed for juice (GSK and NZ Co-Op), powder for capsules, nutriasuiticals marketed by Just the Berries run by the grower David Eder. The Japanese market also takes IQF fruit because of the NZ residue free spray programme and it is growing.

The health aspects of Currants make a great story being told on NZ. This should be told on a global basis. NZ believes USA is a potential market, especially with the capsules. Japan and Asia in general want to consume healthy products, not only juice but fresh, capsules, creams, soap etc. The supermarkets will continue to screw the prices down and therefore the growers must add value as a global industry prior to taking e.g. Black Currants to the market. Generally NZ expect a growing interest for residue free products, added value products and different mixes of soft fruit products as Raspberry, Boysenberry, Strawberry, Currant, Blueberry and Cranberry.

One problem is that too many countries are only selling concentrate for juice. Therefore the supermarkets/chains are controlling the market/prices.

Sustainable production
The production of soft fruit for the fresh market is undergoing a big change. It is only 20 years ago that Integrated Production was introduced at the growers' initiative. The purpose was obviously to secure the quality of the products and production in harmony with the environment. However, the growers were not very easy to convince. The production became more expensive but would they get better paid? The answer is not necessarily yes! It is simply a way to get access to the market, the market told the growers. After some 10 years this is now a fact!

The market itself has worked out a set of rules, Eurepgap, with similar goals. When IP production is more focused on the environment, Eurepgap is more focused on food security.

In the UK the big market chains have put a hard pressure on the producers in order to impress on the consumers. They all have their own environmental profile. They seem to overbid each other. They have since many years set up rules requiring far more documentation and production condition compared to IP. The latest bid is that one of the big chains has promised their customers to sell British produced apples with 0-residue level. This means that pesticides are allowed but only from harvest until flowering. From that on no pesticidal control is allowed.

Organic production
Organic production in soft fruit seems to have come into a dead end. The market in any country is talking about how important organic production is, but in the end of the day nothing really happens. The truth is that they make less money on these products as long as the volumes are low and the price is too high for the customers. There is organic production in all countries but it is generally on a very small scale.

In Sweden some big actors started quite big organic Strawberry production some years ago, parallel to their conventional ones. They had the knowledge, machinery and rationality and they also succeeded well with nice yields and quality. In spite of this, they ended up selling their Strawberry as conventional for logistical reasons. The market does not seem to be ready for this situation. A general opinion is organic production in soft fruit will remain a niche market in most regions.

In soft fruit for processing there seems to be a very small interest in organic production. The interest for IP is also very limited concerning the big crops like Currant, Raspberry and Blueberry. The new small crops are more often connected with organic production. Chokeberry (Aronia), See Buckthorn and Elderberry seem to be excellent for organic farming.

My vision is that the big environmental profits will be gained by the conventional growers who step by step are changing in direction to organic farming. In Strawberry for example the Swedish conventional growers have adopted quite a big use of physiologically active agents against P&D, biological control, damage threshholds, monitoring and control systems and decision support systems. They are on the way, but there still is along way to go.

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The domestication of the cloudberry – soil, NPK fertilization and cultivars

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Abstract
The cloudberry (*Rubus chamaemorus* L.) is one of the most valuable wild berries in Fennoscandia. Great yield variation and lack of pickers encumber the activity of the industry. The domestication of the cloudberry would assure the berry supply because the factors affecting yield variation would be controlled better in fields.

In MTT Sotkamo research station, the prerequisites for cloudberry cultivation were studied from 2001 to 2004 in field trials. Three trials, soil trial, NPK fertilization trial and cultivar trial, are introduced here. In the soil trial, the cloudberry growth and yield were studied in four different soil mixtures. In the NPK fertilization trial, the effect of three levels of N, P, or K, respectively, was studied. In the cultivar trial, four Norwegian cultivars were compared.

The best soil for the cloudberry was a 1:1 mixture of Sphagnum fuscum (Schimp.) Klinggr. and light sphagnum peat. The cloudberry growth in mineral soil (fine sand) was poor. In two other soil mixtures, 1:1 mixture of fine sand and Sphagnum fuscum and 1:1 mixture of fine sand and light sphagnum peat, the growth was intermediate.

Fertilization with N, P, or K did not affect cloudberry yields. However, until 2003, the fertilization did affect the vegetative growth. In 2004, the best shoot density, approximately 600 shoots per square metre, was reached with a planting year soil N content of ≥600 mg/l, P content of ≥30 mg/l, and K content of ≤200 mg/l. These nutrients were only applied separately. Interactions were not studied.

In the cultivar trial, cultivars Fjellgull (female), Fjordgull (female), Apollen (male) and Apolto (male) were compared. The most yielding female cultivar was Fjellgull. No differences in vegetative growth were observed.

In these trials, practical preliminary results for cloudberry cultivation were achieved. However, the ecology and physiology of the cloudberry are still mostly unknown, and more research is needed.

Keywords: Cloudberry, *Rubus chamaemorus*, soil, fertilization, cultivars

Introduction
The cloudberry (*Rubus chamaemorus* L.) is one of the most valuable wild berries in Fennoscandia. Lack of pickers and great yield variation affected mostly by climate, imbalance

between male and female plants, and problems in pollination encumber the activity of the industry. Knowledge of the cloudberry's habitat requirements is also limited. The domestication of the cloudberry would assure the berry supply because the factors affecting yield variation would be controlled better in the cultivation.

The cloudberry is distributed both in the treeless and wooded mires in the northern coniferous forest zone. The rhizomes and roots are perennial, but shoots are annual. Every shoot can produce one flower. Male and female flowers are usually in different clones, but hermaphrodite flowers exist infrequently. The cloudberry is very winter hardy, but sensitive to frost in the growing period.

In MTT Sotkamo research station, eastern Finland, the prerequisites for cloudberry cultivation were studied from 2001 to 2004 in field trials. The measures presented here were a part of the project "Lakka 2002-2004" ("Cloudberry 2002-2004") funded by EU Interreg IIIA Karelia programme and carried out by ProAgria Kainuu and MTT Sotkamo.

The three trials introduced here, soil trial, NPK fertilization trial and cultivar trial, were established in MTT Sotkamo in August 1999 as a part of the project "Lakan (*Rubus chamaemorus* L.) viljely- ja kantavalintakoe 1999-2000" ("The cultivation and variety trial of the cloudberry (*Rubus chamaemorus* L.) 1999-2000") funded by EU Interreg IIA Karelia programme and carried out by ProAgria Kainuu, MTT Sotkamo, and the University of Kuopio.

The purpose of these studies was to find basic knowledge for cloudberry cultivation. In consequence of the research and development projects in the years 1999-2006, the total cloudberry cultivation area in Finland has grown from 0 ha to approximately 4 ha in 2006. The cultivation is still very insecure and more scientific knowledge of cloudberry biology and cultivation is needed.

Material and methods

In the summer 1999, the cloudberry experimental field was established in the MTT Agrifood Research Finland, Sotkamo research station (64° 6' P, 28° 20' I, 157 m above the sea level). In this experimental field, during the years 1999-2005 three trials, a soil trial, NPK fertilization trial and cultivar trial, were carried out. The measurements presented here were done in the years 2001-2004.

The cloudberry plants were planted in August 1999 to black barrels, which were embedded to soil. The basal area of one barrel was 0.238 m^2 and depth 58 cm. The water table was set to the depth of 30 cm by using underdrainage. No chemical plant protection was used and weeds were removed by hand. The soil trial and cultivar trial were not fertilized during their existence. In the NPK fertilization trial and cultivar trial, the soil was light sphagnum peat, the decomposition level of which was H3-H4.

In the soil trial, the cloudberry growth and yield were studied in four different soil mixtures: 1) Muddy very fine sand, 2) Muddy very fine sand 50 % + *Sphagnum fuscum* 50 %, 3) Muddy very fine sand 50 % + light sphagnum peat 50 % and 4) light sphagnum peat 50 % + *Sphagnum fuscum* 50 %. The female cultivar was Fjordgull (four plants per barrel) and the male cultivar was Apollen (one plant per barrel). The experiment was set up in a randomized complete block design with five blocks and four soil treatments.

In the NPK fertilization trial, the effect of three levels of N, P, or K, respectively, was studied. In the beginning of the trial, the different treatments were fertilized as follows: 1) N 200 mg/l, 2) N 400 mg/l, 3) N 600 mg/l, 4) P 10 mg/l, 5) P 20 mg/l, 6) P 30 mg/l, 7) K 200 mg/l, 8) K 400 mg/l, and 9) K 600 mg/l. Before the fertilization the soil nutrient levels were N <1 mg/l, P <1 mg/l, and K 16 mg/l. The female cultivar was Fjellgull (four plants per barrel) and the male cultivar was Apolto (one plant per barrel). The experiment was set up in a randomized complete block design with five blocks and nine fertilization treatments.

In the cultivar trial, Norwegian cultivars Fjellgull (female), Fjordgull (female), Apollen (male) and Apolto (male) were compared. The experiment was set up in a randomized complete block design with five blocks and four cultivar treatments. In one barrel, four plants of one cultivar were planted. Contrary to the other trials, no male cultivars were planted to the same barrels with female cultivars.

In the years 2001-2004, the number of berries, total yield (g) and number of shoots in the end of the growing season were measured. For statistical analyses, the analysis of variance was performed by using the Mixed procedure of the SAS 8.2 statistical software. The significance level used for all tests was 0.05.

Results

Soil trial

The soil trial yielded in the years 2003 and 2004. The best soil for the cloudberry was a 1:1 mixture of *Sphagnum fuscum* and light sphagnum peat (Table 1). The cloudberry growth and yield in mineral soil (muddy very fine sand) were poor. In two other soil mixtures, 1:1 mixture of fine sand and *Sphagnum fuscum* and 1:1 mixture of fine sand and light sphagnum peat, the growth was intermediate.

Table 1. The yield results of the cloudberry soil trial in 2003 and 2004. For each class, the values marked with the same letter are not significantly different ($p<0.05$). FS = muddy very fine sand, SSF = 1:1 mixture of fine sand and *Sphagnum fuscum*, FSP = 1:1 mixture of fine sand and light sphagnum peat, SFP = 1:1 mixture of *Sphagnum fuscum* and light sphagnum peat.

		Soil			
	Year	FS	SSF	FSP	SFP
Yield g/m^2	2003	1.6a	52.0b	3.8a	91.3b
Yield g/m^2	2004	0a	14.4a	0a	27.5a
Nr of fruits / m^2	2003	1.7a	35.4b	8.4a	67.3c
Nr of fruits / m^2	2004	0a	11.8a	0a	23.6a

Table 2. The vegetative growth results (number of shoots per m^2) of the cloudberry soil trial from 2001 to 2004. For each class, the values marked with the same letter are not significantly different ($p<0.05$). FS = muddy very fine sand, SSF = 1:1 mixture of fine sand and *Sphagnum fuscum*, FSP = 1:1 mixture of fine sand and light sphagnum peat, SFP = 1:1 mixture of *Sphagnum fuscum* and light sphagnum peat.

		Soil			
	Year	FS	SSF	FSP	SFP
Nr of shoots / m^2	2001	8.4a	62.3a	37.0a	64.0a
Nr of shoots / m^2	2002	45.5a	238.2b	235.7b	303.1b
Nr of shoots / m^2	2003	28.6a	207.1b	141.4b	262.6b
Nr of shoots / m^2	2004	20.2a	235.7b	158,3b	282.8b

Fertilization trial

The fertilization trial produced yield in 2003 and 2004. In both years, fertilization with nitrogen, phosphorus or potassium did not affect the number of fruits or the total mass of the yield. In 2003, the mean yield was 51.5 g/m^2 and the number of fruits was on average 40.6 fruits per m^2. In 2004, the mean yield was 46.3 g/m^2 and the number of fruits was on average 50.6 fruits per m^2.

In the years 2001, 2002, and 2003, fertilization did not affect shoot growth. In 2001, the mean shoot number was 69.7 shoots per m^2, in 2002 347.3 shoots per m^2 and in 2003 230.8 shoots per m^2. The fertilization with nitrogen and phosphorus increased the shoot growth in 2004, but the potassium fertilization had no impact and a good yield was achieved already with the lowest fertilization level (Table 3).

Table 3. The vegetative growth (number of shoots per m^2) in the fertilization trial in the year 2004. For each class, the values marked with the same letter are not significantly different ($p<0.05$).

	The fertilization level (1=lowest, 3=highest)		
Nutrient	1	2	3
N	21.0a	258.9bc	675.6d
P	267.3bc	229.4ab	629.3d
K	608.2d	629.3d	467.2cd

Cultivar trial

The female cultivars Fjellgull and Fjordgull produced yield in 2003 and 2004. The best-yielding cultivar was Fjellgull (Table 4). The shoot growth was measured from all the cultivars (Fjellgull, Fjordgull, Apollen ja Apolto) and no differences were observed. In 2001, the mean shoot number was 54.3 shoots per m^2, in 2002 291.7 shoots per /m^2, in 2003 144.6 shoots per m^2 and in 2004 608.6 shoots per m^2.

Table 4. The yield of the female cultivars in the cultivar trial in 2003 and 2004. For each class, the values marked with the same letter are not significantly different ($p<0.05$).

	Year	Cultivar Fjellgull	Fjordgull
Yield g/m^2	2003	81.4a	17.6b
Yield g/m^2	2004	135.6a	48.0b
Nr of fruits / m^2	2003	50.5a	12.6b
Nr of fruits / m^2	2004	136.4a	34.5b

Discussion

Presumably, the cloudberry needs good air porosity of the soil. Based on these results, an ordinary arable land with mineral soil is not suitable for cultivation. In this trial, the best soil mixture was that with the best air porosity, 1:1 mixture of *Sphagnum fuscum* and light sphagnum peat. In the cultivar trial, only light sphagnum peat was used, but results cannot be compared to the Fjordgull treatment of the cultivar trial, because the planting density and pollination conditions were different.

In Norway, the best growth of the cloudberry is achieved in the light sphagnum peat, whose decomposition level is H1-H4 (Dr. Kåre Rapp, personal communication to Heli Pirinen in 1999). In the peat with low decomposition level, the air porosity is high and that information is compatible with our results. The cloudberry could also be grown in a coarse-grained mineral soil, perhaps, if water availability would not limit the growth. On the other hand, also other peat related factors may affect the cloudberry's survival. In practice, peat is the most economical growing media, presumably.

Because the normal mineral soil is not suitable for growing cloudberries, the large-scale cloudberry cultivation should be concentrated to boggy areas. Therefore, the cloudberry would only seldom be a part of the traditional soft fruit farm's supply.

In the earlier studies of the cloudberry, fertilization, nitrogen, phosphorus and potassium have shown, alone or together, a positive effect or no effect on yield (Rapp 1989, Kortesharju 1986, Kortesharju & Mäkinen 1986, Kortesharju & Rantala 1980, Østgård 1964, Lid et al. 1961). The purpose of our fertilization trial was to examine whether nitrogen, phosphorus or potassium is the minimum factor of the growth. In this case, fertilization did not affect the yield and the effect on vegetative growth was observed only in the last year of the trial. Then, all the studied nutrients affected cloudberry growth, but already the lowest level of potassium gave as good a result as the highest levels of nitrogen and phosphorus.

In this trial, these nutrients were only applied separately and interactions were not studied. Also the absence of the 0-levels makes conclusion-drawing difficult. Results cannot be compared to the Fjellgull treatment of the cultivar trial, because the planting density and pollination conditions were different.

In Norway, Rapp (1989) recommends the fertilization of N 4-8 kg/ha, P 2-4 kg/ha and K 5-10 kg/ha every tenth year. In this trial, the fertilization levels were remarkably higher. The need for fertilization in a soft fruit cultivation is generally low and, especially in cloudberry

cultivation, the nutrient amounts the plant uses for growth and yielding are very low. Generally, the soil nutrient levels of the cloudberry's natural habitats are very low.

The cloudberry cultivars Apollen, Apolto, Fjellgull and Fjordgull were published in Norway in 1991 (Rapp & Martinussen 2002, Rapp 1991). The Norwegian breeder of the cultivars, Bioforsk Nord Holt research station, recommends Fjellgull to inland areas and Fjordgull to coastal areas. Our experimental place was located in 64° 6' N, 28° 20' E, 157 m above the sea level and 200 km to the coast. In our location, the inland cultivar Fjellgull was the best. The Bioforsk Nord Holt recommends Apolto as the primary pollinator regardless of location. In this study, we did not compare the pollination capability of the male cultivars.

Conclusions

An ordinary arable land with mineral soil is not suitable for cloudberry cultivation. In this study, the best soil mixture for the cloudberry was that with the best air porosity. In this study, the fertilization with nitrogen, phosphorus and potassium affected only vegetative growth and a fertilization recommendation could not be given. In the cultivar trial in eastern Finland, the inland cultivar Fjellgull was the best.

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